ECE 435

S-Parameters of Cascaded 2-Port Networks

Latest revision: August 1995

In this lab you will measure the S-parameters of cascaded 2-port networks using the vector voltmeter. You will show that the S-parameters of two individual networks can be used to calculate the S-parameters of the cascaded network formed from the two individual networks.

NOTE: BE SURE THAT YOU AND YOUR LAB PARTNER ARE GROUNDED THROUGH WRIST-STRAP CONNECTORS. THE VECTOR VOLTMETER INPUT CIRCUITS ARE STATIC SENSITIVE!

Preliminary

Consider a T-network consisting of 22Ω resistors as shown in Figure 1. Calculate the Z-parameters of this 2-port network by forming the circuit equations for the circuit shown in Figure 2.

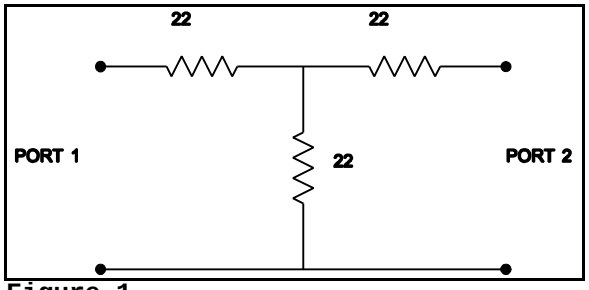

Figure 1.

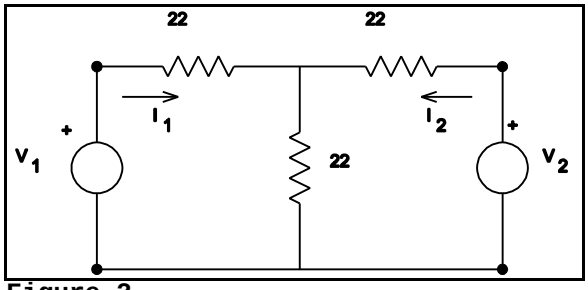

Figure 2.

Procedure

Students should split into four groups of two (or occasionally three). Since there are only six directional couplers, two groups will do the S_{11} and S_{22} measurements while the other groups do the S_{12} and S_{21} measurements.

A) Run the automated measuring program "S.EXE" directly from the C:\USR directory and measure S_{11}, S_{12}, S_{21} and S_{22} for both the T-network and the low pass filter (LPF) at 100

MHz and 2000 MHz. Record each result. The T-network is contained inside the GR 874-X insertion unit. **Be sure to note which end of each device is Port 1 and which is Port 2.** The S-parameters of the cascaded network depend on the orientation of the individual networks.

B) Form a cascaded network by attaching Port 2 of the T-network to Port 1 of the LPF. Port 1 of the T-network is now considered Port 1 of the cascaded network, and Port 2 of the LPF is now Port 2 of the cascaded network. Measure S_{11}, S_{12}, S_{21} and S_{22} of the cascaded network at 100 MHz and 2000 MHz. Record each result.

C) Run the program "2PORT.EXE" directly from the C:\USR directory. This program converts between each of four types of network parameters (Z, Y, S and ABCD parameters), calculates ABCD-parameters for several standard 2-Port networks, and calculates the ABCD-parameters for cascaded 2-Port networks by multiplying their ABCD matrices. Two 2x2 network matrices may be handled simultaneously, one labeled A and the other B.

D) Fill the matrix A with the ABCD-parameters of the standard T-network you analyzed above. (Note that all input and output in 2PORT.EXE is in mag/phase (deg) form.) Write down the ABCD-parameters and then convert the matrix to Z-parameters. Write down the Z-parameters and then convert to S-parameters. Write down the S-parameters. How do the Z-parameters compare to those calculated in the preliminary?

E) Fill the matrix A with the S-parameters measured at 100 MHz for the LPF. Convert these to ABCD-parameters and store in matrix B. Fill the matrix A with the S-parameters measured at 100 MHz for the T-network. Convert these to ABCD-parameters and then form the ABCD matrix for the cascaded network by multiplying A and B. Finally, convert the ABCD-parameters of the cascaded network to S-parameters. **These S-parameters should match fairly well the measured parameters for the cascaded network. DO NOT finish the lab until you have a match.** If your match is not good, you have either mismeasured the parameters or have made a mistake running 2PORT.EXE. You do NOT have to repeat the calculations for 2000 MHz.

F) Dismantle the T-network and note the geometrical configuration of the resistors. Reassemble the network carefully, making sure the GR connector rings are tight.

Report

1. Compare the theoretical Z-parameters calculated by solving the circuit in Figure 2 with those found using 2PORT.EXE.

2. Compare the MAGNITUDES of the S-parameters of the T-network measured at 100 MHz with those found using 2PORT.EXE. Compare the PHASES of the S-parameters of the T-network measured at 100 MHz with those found using 2PORT.EXE. Which matches better, the magnitude or phase? Explain why.

3. Repeat part (2) for the S-parameters measured at 2000 MHz. Why do you think that neither the magnitude nor phase matches well at 2000 MHz? Remember what the network looked like when you examined it. Does this say something about the behavior of lumped elements at microwave frequencies?

4. Compare the S-parameters of the cascaded network measured at 100 MHz with those found by multiplying the ABCD matrices of the individual networks.

5. Examine S_{12} and S_{21} for the cascaded network at 2000 MHz. How does the presence of the LPF effect the behavior of the cascaded network?

EQUIPMENT LIST

S-Parameters of Cascaded 2-Port Networks

1	HP 8657B signal generator
1	HP 8508A vector voltmeter with 85082A input module
2	HP 778D dual directional couplers
1	N(F)-BNC(F) adapter
6	N(M)-BNC(F) adapters
4	N(M) 50 Ω terminations
2	N(F)-N(F) adapters
1	N(M)-N(M) adapter
1	GR 50 Ω termination
1	N(M)-GR adapter
1	N(F)-GR adapter
1	GR WN short circuit termination
1	N(M) short circuit termination
1	GR 874-F1000 low-pass filter
1	GR 874-X insertion unit containing 22 Ω T-network
2	grounding wrist straps
	BNC cables as needed

NOTES:

1. Type N cables can be substituted for BNC cables with the elimination of several N-BNC adapters.

2. There will not be sufficient components for four complete stations. Students will have to share several items.